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ABSTRACT

The four units in this workbook (units 2, 3, 5, and 9) are part of a larger 14-unit course in horticulture. The topics are plant classification, the plant cell, complex compounds, and vegetative growth and development. Student learning in these fields is frequently low in the traditional lecture-laboratory setting. These materials are designed for remedial students to supplement their regular course of study in an effort to further improve their skills. Each workbook unit contains a script for an accompanying tape (not available here), diagrams to illustrate portions of the text, and a glossary. (YLB)

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FINAL REPORT

Audio-Tutorial Horticulture Learning Units

Project No. 82-131/132-600-11 (149-151)

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St. Louis Community College at Meramec
Kirkwood, Missouri

July 5, 1982

Missouri Department of Education
Research Coordinating Unit
Jefferson City, Missouri 65102

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ABSTRACT

This project involved the development of four units of Audio-Tutorial Introductory Horticulture. These units are part of a larger 14 Unit course in Horticulture taught by the Horticulture Departments at Meramec College. These four units of work are units in which student achievement is frequently low in the traditional lecture-laboratory setting. These four units will be available for student remedial and supplemental study, either as take home units of work or for use in the campus Library. It is hoped that these units will significantly improve student achievement in these areas.

Each unit consists of a script, which will be recorded on tape, and a work book to accompany the script. A glossary of terms is also to be found at the end of each work book unit.

The titles of these units of work are as follows:

Unit Two: Plant Classification

Unit Three: The Plant Cell

Unit Five: Complex Compounds

Unit Nine: Vegetative Growth and Development

Statement of the Problem:

Many students begin vocational horticulture with little or no background in Science. At Meramec College, one of the first required courses in horticulture is a course in Introductory Horticulture which presents many basic horticulture and biological concepts. Many students have difficulty achieving in this course. The course is organized into 14 units of work and four of these units were developed into an Audio-Tutorial format last year. This work was funded by a grant from Meramec College. These units were used as remedial and supplemental study and were so helpful that it was decided to develop four more units for a total of eight, which will be available for the 82-83 academic year.

Objectives:

The primary objective of this project was to provide four additional units of Audio-Tutorial work for students in the Introductory Horticulture course for use as remedial or supplemental study. It is hoped that these units will help improve student achievement in the course and decrease the drop-out rate.

Population:

These units will be available for use by a student population consisting of beginning freshman students in the horitculture program at Meramec College during the 82-82 academic year.

Conclusion and Recommendations:

During the 82-83 academic year, a survey will be made as to student utilization frequency of these units. Also a follow-up questionaire will be developed to obtain feedback as to student perceptions about the effectiveness of these units and where they might need revision. These results will be evaluated and a judgement made as to the advisability of developing the remaining six units.

Disclaimer:

"The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Career and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Career and Adult Education, and no official endorsement should be inferred."

INTRODUCTORY HORTICULTURE

UNIT TWO SCRIPT

PLANT CLASSIFICATION

The science of the identification and classification of living things is known as Taxonomy. To understand and use the various plants found on the earth is is essential to arrange them in an orderly system of classification and to give each species a name and only one name that refers only to that species. The great French Taxonomist De Condolle said in 1886 in his book "The Origin of Cultivated Plants; "Science can make no real progress without a regular system of nomenclature." Plant taxonomists work to identify the different species of plants and to classify each species so as to show its true relationship to all other plant life. Modern taxonomists then, use all possible information including morphology, anatomy, physiology, cytology, biochemistry and geographic distribution. Because taxonomy encompasses and uses information from all the other branches of science, it is frequently called the King of the sciences.

Good taxonomy requires a large library of the existing and past works on plant classification. It also requires a large herbarium. A herbarium is a collection of pressed plant specimens which act as the basic material in the plant classification process.

Scientific names become very important in horticulture. Horticulturists across the world communicate plant names to one another in a exact and precise nature by using scientific names.

If properly used, there is no confusion among horticulturists as to what plant is being discussed. If a package of seeds is mailed by a horticulturists in Japan to a horticulturist in the United States, the recipient can know exactly what that plant will be and how it will look, even before planting the seed.

Of course, taxonomists have a larger goal, than the goal of identification of plants. Taxonomists hope that out of the maze of diversity found in the living plants of the world, that they will be able to reconstruct a evolutionary history, which correctly shows the relationship of each species of plant to all other species.

We now want to take a moment to look at the systems of classification and how we arrived at our presently accepted system of classification.

The earliest systems of classification were used by the Greek philosophers and Greek doctors. These Greeks classified plants by a method that is called an artificial method. They classified a plant on the basis of its vegetative characteristics, such as growth habits, leaf structure. Theophrastus (370-285 B.C.) was a Greek naturalist. He wrote De Historia Plantarum, the oldest existing botanical book. He classified 480 species of plants as herbs, undershrubs, shrubs and trees. He recognized groups of species which we collectivelly call genera. He also recognized the family level of taxonomy, which consists of many related genera.

During the middle ages almost all learning was confined to work by church monks. They used Theophrastus as a basis for classification. The chief use of classification during the middle ages was to identify medicinal plants. We must remember that the only source of pharmacological material came from plants or plant

gardens and museums as a result of the European explorations and conquests. These plants were identified mostly by local common names and attempts to incorporate them to the existing taxonomic structure was almost a complete failure. Linnaeus, in one mammoth work: established a workable method of naming plants, integrated all known plants in a common taxonomic system; and established a new system of classification, most of which is still in use today. It is no wonder that we still refer to Linnaeus at the "Father of Botany." The natural system of classification, which developed after Linnaeus, arranged plants into a system of classification using external and internal anatomic and morphological features. The one flaw to this system was it failed to recognize that plants can change in form and shape as they adapt to changes in environmental conditions. These scientists did not attempt to establish plant groups which reflected the plants past geneology.

The system of plant classification used today is called a Phylogenic system. It is different from the natural system in two ways. First, it attempts to classify plants in groups which reflect geneologic relationships; and secondly, it uses all scientific information available in order to reach these conclusions. Not only is morphological and anatomical information used; but also, genetic, biochemical, cytological, and physiological information is used. In addition, the geographic distribution of plants has become an important feature.

August Eichler in 1875 published a work outlining the basis for our present day phylogenic system of plant classification.

derivatives at this time. Furthermore doctors had very little training in human internal anatomy and spent most of their schooling learning about how to collect, prepare and use medicinal plants. Church law atated that the human body was sacred and even after death it could not be dissected for any purpose. So doctors had almost no knowledge of human internal structure and anatomy.

Monks classified plants as to their medicinal use by writing large books called herbals. They were, of course, all done by hand and had a wood cut picture of the plant in question, along with a description of that plant and what human ills it would cure. It would also contain information on where to find the plant and how to prepare it for medicinal use. It was believed, in the middle ages that medicinal plants had curative properties assigned by God on the basis of plant form. For example if a plant had a heart-shaped leaf, it would be used to cure heart disease. Plants which we call liverworts, were given their name during the middle ages because the plant was liver-shaped and therefore could be used to cure liver ailments.

The second system of classification used by Taxonomists was a system called a natural system. Carolus Linnaeus, the famous Swedish botanist, established the principles for this method in "Species Plantarium," a monumental work in which Linnaeus classified and described all known living plants. In this work Linnaeus formed all the major taxonomic units used today. Classes, Orders, Families, and Genera. He also instituted the binomial system of nomenclature which is universally in use today. By 1700 European plant taxonomy was in a state of near collapse. Thousands of new species of plants had flooded into European Botanical

Two of Eichler's students, Engler and Prantle, published the 20 volume classic "Die Naturlichen Pflanzenfamilien" in 1892. In this work, all of our now accepted taxonomic groups were established. Such groups as the conifers, flowering plants, monocots, and dicots were formed. We now want to look a little closer at plant taxonomy.

Plant taxonomy is a heirarchial system. By this we mean it is organized much like an army where small basic units are gathered under a larger unit and those larger units are in turn gathered in even larger units.

One big difference between a military heirarchial system and man's taxonomic system is that in a military system each sub-unit has a prescribed and predictable number of sub-units; while in biological taxonomy, no such predetermined number in each sub-unit exists. Biological taxonomic units resemble an army after a war. Certain units survive almost intact, while other units may have been almost completely decimated. Now the force which decimated the biological army was nature, who by her ever changing environment and subsequent production of new, more-favorably adapted species, caused numerous older units or species to become obsolete and extinct.

Turn to diagram 2.1 which outlines the major taxa in plant taxonomy. Any unit in a classification system is called a Taxon. (A Taxon was a company of soldiers in the ancient Greek army.) Just for fun, we are going to classify an apple. An apple belongs to the Plant Kingdom, division Spermatophyta or the seed plants. It further belongs to the class Dicotyledomeae, or seed plants

having two seed leaves formed inside the seed. It further belongs to the order Rosales and the family Rosaceae, or rose family. It also belongs to the genus malus, which is Latin for apple and is the species Malus domestica or the domesticated apple.

You will note that each unit has several lines from it which have no names. This indicates that this system is much more complex and has many taxa that are not shown. For example, the family Rosaceae is a very large family comprising a hundred or more genera, which are in turn subdivided into groups called sub-families. Also it is important to know that each taxon above the genus has its own ending. A division always ends with "phyta" while a class always ends in "doneae." An order always ends in "ales" and a family in "aceae" or "ateae." For horticultural purposes, we may extend the classification system below the species level to include varieties and clones. For example, we all know there are many varieties of domesticated apples.

It is important to keep in mind that this entire system is man-made except for the species. Species are formed by nature over years of evolution but all the other taxa are created by man to be used by him to organize and classify the world of plants.

Linnaeus was very concerned about species identification and naming. At the time he wrote his Species Plantarum, the naming of species was in a state of chaos. About the only way one could be sure a person would know which species you were refering to in a letter or a scientific paper would be to describe the species in an exact scientific description. This was a long and time consuming

process. Linnaeus established the binomial system of species naming. Binomial means two names. Linnaeus's system of nomenclature was universally adopted and is still in use today. He said that the following rules would apply to his system:

1. Every plant species shall have only one name.
2. This name shall be a two-word name.
3. This name shall be in Latin because Latin is a dead language and will not change in meaning; furthermore, it is the universal language of scholars and can be understood world-wide.
4. The first word will also indicate the genus to which the plant belongs and it will always be a noun and begin in upper case letters.
5. The second name is an adjective and usually modifies the noun. It should begin in lower case letters, except when it indicates a person for whom the species is being named.

Both words together make up the species name. The species name is always italisized or underlined when it is found in a written text. The second word in the scientific species name is usually chosen by botanists to indicate some important feature of the plant which will help in the identification of the plant. Let's look at diagram 2.2 which shows several species names. The first species is the cultivated apple. The genus name means apple in Latin and the second word means cultivated. Obviously the second word "domestica" means nothing by itself. Also, you will notice that we have added something to the species name in that at the end you will find an upper case "L" with a period. This is called an author reference, and it indicates the name of the author who described and named this species. In this case it was Linnaeus. The next species is Tradescantia virginiana L. This species is named after the French botanist Tradiscant and the species is found in Virginia. Again

The third species is Cattleya Skinneri. The genus Cattleya is a genus of orchids named after Sir John Cattleya of England who first cultivated these plants. Skinneri is the name of Mr. Skinner who first collected this species in Central America in 1820. You will note that the last word begins in upper case because it is a person's name. Also, the author index is "Lind." This is an abbreviation for Sir John Lindey, a famous English botanist who first identified, named and described this species.

Many times in horticulture, when a species is referred to in writing or in a catalogue, the auther reference is dropped. In formal botanical literature, however, it must always be included. The author reference is very important in identification of plants. Suppose someone brought you a twig of an apple and asked you for an identification and that you could not decide if it was a cultivated apple or an ornamental apple from China. By knowing the author reference, you could go to a botanical library, such as at the Missouri Botanical Garden, and find the section containing the works of Linnaeus. Then, you could look up the original description which Linnaeus gave to Malus domestica and determine if your specimen was truly a cultivated apple.

In addition to botanical descriptions, the botanist or horticulturalist has another valuable tool to aid in plant identification and classification. This is the herbarium. The herbarium is a collection of pressed plant specimens. These specimens are almost indistructable and so have an unlimited time in scientific use. Herbarium speciemens of plants collected by Charles Darwin in his famous trip on the British Royal Ship HMS Beagle are still in use.

These herbarium specimens must always be properly labeled and noted as to the location and date that the plant was collected. If you were interested in finding out the range of variation in fruit size or fruit color in the domesticated apple, an herbarium collection would provide you with that information. If you were interested in knowing which countries of the world cultivated the apple, an herbarium would help you. And finally, if you wanted to identify a specimen of Malus domesticus that you could not positively identify from a botanical description, then an herbarium specimen would help.

We want to note that their is one herbarium specimen of a species that is most important. This is the type specimen. The type specimen is the herbarium specimen that was used by a botanist when he wrote the official botanical description of the species for publication. It is important because it is the last word in identification of that species. Type specimens are very valuable and usually the scientific worth of a herbarium is related directly to the number of type specimens it contains.

Horticulturists have been selecting and breeding plants which have specific characteristics which are important horticulturally. These selected forms of a species which have desirable characteristics are called cultivars. New cultivars are constantly being developed to improve the quality of a crop or permit wider climatic adaptations. Cultivars are indicated by the prefix cv in lower case letters before the name of the cultivar. Look at diagram 2.3 in your lab manual and we can see the correctly written designation of Jonathan apple. In real practice, the designation cv is usually

dropped, and it would be an unusual catalogue or plant label which would read Malus domestica cv Jonathan.

Now we find two types of cultivars. The first is the type of cultivar which is propagated only from cuttings. It may be a human creation or it may be selected from the wild. It is called a clone. A clone is a population of plants, all of which were derived from a single plant by vegetative means. The plants of a clone are genetically homogeneous, providing, of course, no mutations have taken place in any of these plants. A clone can be designated by the prefix cl. Diagram 3.4 in the lab manual shows the Jonathan apple written as a clone.

The other type of cultivar is a population of plants which are identical to each other but which are propagated by seed. This cultivar is called a line, and a line can be identified by using the designation ln. Diagram 2.5 shows the correct designation for Seneca Chief, a sweet corn seed line cultivar. You will note that cultivated corn is a species known as Zea mays. Again in practice, most horticulturists omit the use of cl and ln designations in their catalogues or on labels.

We have one more group of plants whose correct labeling needs to be discussed. This is the hybrids. Hybrids are easier to produce in the Plant Kingdom than in the Animal Kingdom. Hybrids are usually produced between two species or between two inbred lines. Look in your work book at diagram 2.6 which shows a hybrid clematis. This hybrid is named Clematis X jackmanii and it is a cross between C. lanuginosa and C. viticella. The X before the word jackmanii indicates that this plant is a hybrid.

One of the most important features of a plant that aids in its identification is the flower. It is considered by botanists to be a structure which does not change, even when it is found under a wide variety of environmental conditions. We will be discussing flower form and type in a subsequent unit. Another structure which is most important in plant identification is a plant's leaves. They can aid in identification even though the plant may not be in flower. Most leaves have two basic parts. The large flat round surface where most of the photosynthesis occurs. It is called the blade. And the thin wire-like part attached to the branch called the petiole. Diagram 2.7 illustrates these two parts of a leaf. Some leaves lack a petiole. Diagram 2.8 shows a leaf without a petiole. This is known as a sessile leaf.

Leaves are frequently classified as to their arrangement on the stem. Leaves can be arranged on the stem in three ways: alternate, opposite and whorled. In the alternate arrangement, the leaves appear to alternate back and forth on either side of the stem. Diagram 2.9 in the workbook shows an alternate arrangement. Are the leaves in diagram 2.9 complete or sessile? That's right, they have no petioles and they are sessile. In the opposite arrangement, the leaves are arranged in pairs along the stem. Diagram 2.10 in the workbook illustrates the opposite arrangement. The third arrangement, which is called whorled, has three or more leaves found at a node. Diagram 2.11 shows the whorled condition.

By the way, a node is the place on the stem where a leaf is attached. The stem is usually enlarged at this spot and we always find a bud. In some cases more than one bud can be present.

There are two kinds of leaf blade configuration: simple and compound. In a compound leaf, the blade is divided into a number of separate leaf-like parts called leaflets. When the leaflets arise from the central mid-rib of the leaf blade, as in diagram 2.12, the leaf is said to be pinnately compound. When the leaflets diverge from a common point at the end of the petiole, the leaf is said to be palmately compound. Diagram 2.13 shows the palmately compound condition.

Frequently we classify plants according to their seasonal growth patterns. In this classification, plants are either annual plants, biennial plants or perennial plants. An annual plant is one which completes its entire life cycle in one growing season. The seed germinates, the plants produce a vegetative phase, a flowering phase and a fruiting (or seed producing) phase and then dies. A biennial plant completes its life cycle in two growing seasons with usually a cool winter period separating the two seasons. The first season, the seed germinates and the plant completes its vegetative phase. The plant waits over winter and in the second growing season goes through the flowering and fruiting stages and then dies. In a perennial plant, a life cycle is completed each year, but the main body of the plant remains alive each year; therefore, it completes many, many life cycles year after year. An example of an annual plant would be a garden Merigold. An example of a biennial plant would be a lettuce plant. And an example of a perennial plant would be a peach tree or an iris plant.

This is the end of tape number two. Would you please turn off your tape recorder.

HORTICULTURE I

UNIT 2

PLANT CLASSIFICATION

Educational Objectives

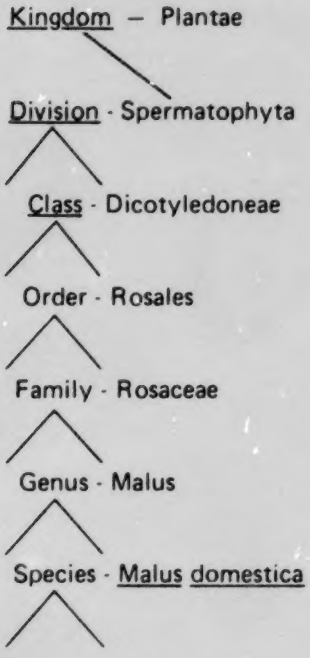
1. To know that plant taxonomy is the science of the classification of plants.
2. To know why scientific names of plants are necessary.
3. To know the three systems of plant classification.

   a. Artificial; using arbitrary characteristics.
   b. Natural; using selected morphological structures.
   c. Phylogenetic; based on genetic relationships.
4. To know that an artificial system was used by the Greeks.
5. To know that a natural system was used by Linnaeus in Species Plantarum, 1753.
6. To know that a phylogenetic system was introduced by August Eichler in "Die Naturlichen Pflanzenfamilien" in 1875. (published by Engler and Prantl)
7. To know that plant taxonomy is a heirarchial system.
8. To know the major divisions of the taxanomic system; Kingdom, Division, Class, Order, Family, Tribe, Genus, and Species.
9. To know why the species is the only classification unit that occurs in nature.
10. To know that Linnaeus introduces the binomial system of plant nomenclature.
11. To know that the binomial system used a latin, two-word name.
12. To know that the first word in the binomial is the genus to which that species belongs.
13. To know that the second word usually modifies the first word, and that both together make-up the species name.
14. To be able to describe the author reference and why it is important.
15. To be able to define a herbarium and a herbarium specimen.
16. To be able to describe a type specimen and know how it is used.
17. To know how to define a cultivar.
18. To know the difference between a clone cultivar and a line cultivar.
19. To be able to designate a hybrid.
20. To know the different types of leaf arrangement; alternate, opposite, or whorled.
21. To be able to distinguish a compound from a simple leaf.
22. To be able to define an annual plant, a biennial plant, a perennial plant.

UNIT 2

PLANT CLASSIFICATION

2.1: MAJOR TAXANOMIC TAXA



2.2: SPECIES NAMES

Malus domestica L.

Tradescantia Virginiana L.

Cattleya Skinneri Lind.

2.3: CULTIVAR MALUS DOMESTICA CV Jonathan

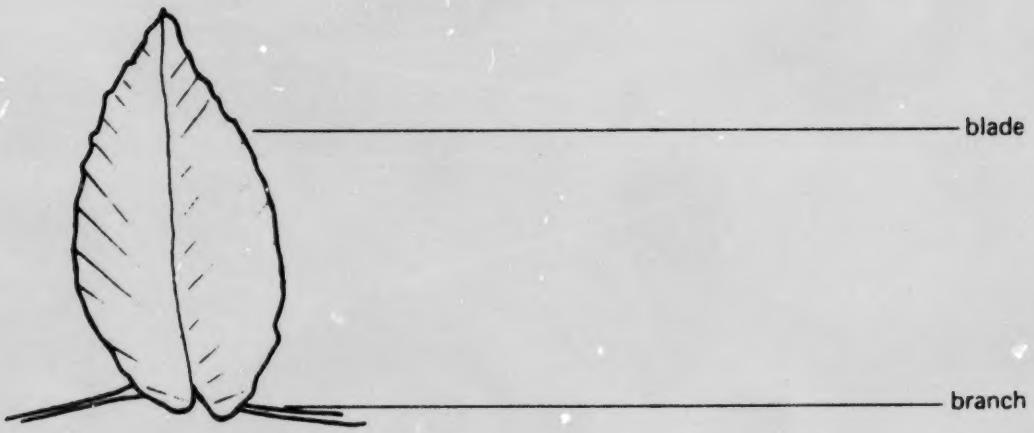
2.4: CLONE CULTIVAR MALLUS DOMESTICA CL Jonathan

2.5: LINE CULTIVAR ZEA MAYS LN Seneca Chief

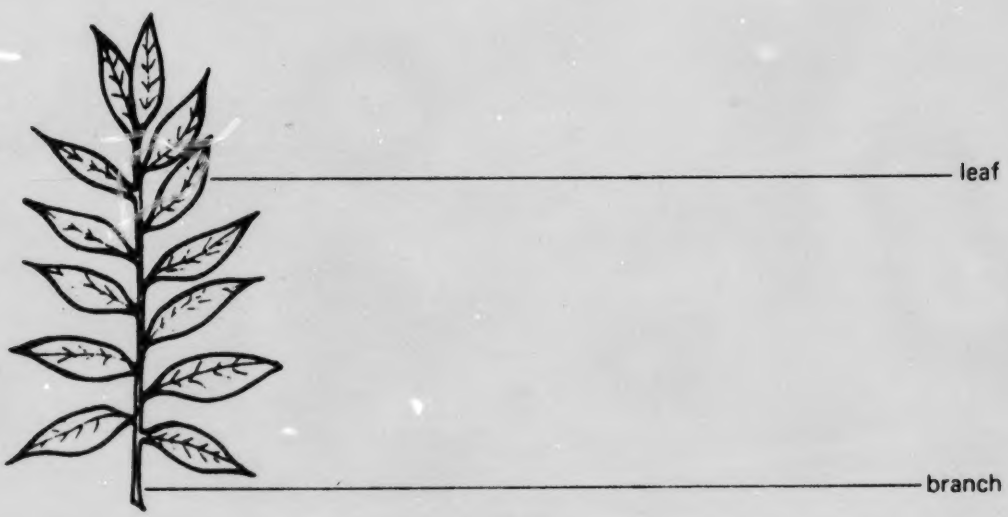
2.6: HYBRID PLANT CLEMATIS X JACKMANII (C. lanuginosa X C. viticella)

2.7: COMPLETE LEAF

2.8 SESSILE LEAF

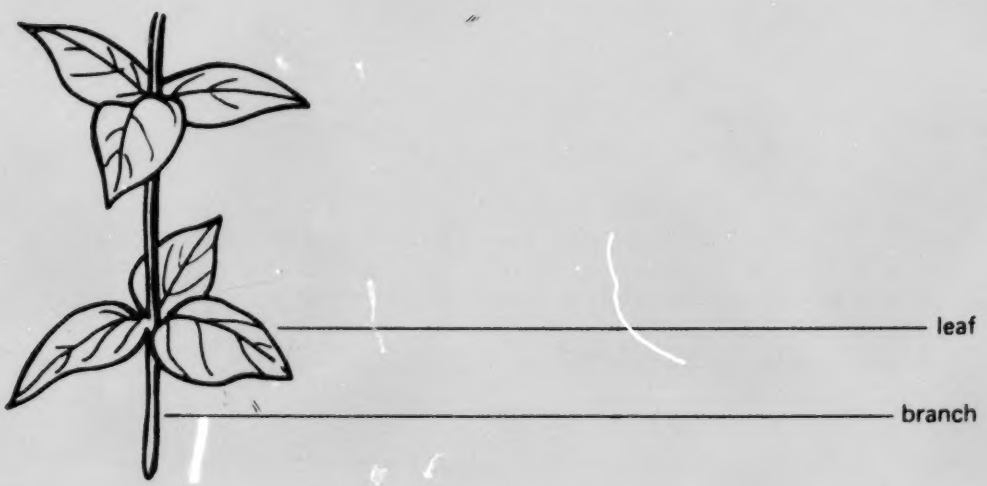


2.9 ALTERNATE LEAF ARRANGEMENT



2.10: OPPOSITE LEAF ARRANGEMENT

2.11: WHORLED LEAF ARRANGEMENT



2.12: PINNATELY COMPOUND LEAF

2.13: PALMATELY COMPOUND LEAF

GLOSSARY: UNIT TWO

Clone: A population of individuals all of which are propagated asexually from one ancestor.

Inbred Line: A population of individuals all of which were produced from a series of inbred generations selected for specific traits.

Pharmacological: Pertaining to medicinal or curative features.

Species: An population of individuals who are inbreeding and all of whom have the same germ plasm.

Taxon: Any unit in a classification system.

Taxonomy: The science of the naming and classification of living organisms.

INTRODUCTORY HORTICULTURE

UNIT THREE SCRIPT

THE PLANT CELL.

All higher plants are composed of cells and cell products. The purpose of this unit is to give you a body of information about how plant cells function and the various types of cells found in a mature higher plant. The generalization that all organisms consist entirely of cells and cell products is known as the cell theory. It was formulated in 1838 by the German biologists,Schleiden and Schwann, and it soon became one of the fundamental cornerstones of modern biology. Virchow is 1855, added a second tenant to the cell theory by stating that all cells come from pre-existing cells.

All plant cells are basically similar in their physical organization and bio-chemical properties; but as these cells mature and differentiate, each cell develops in an individual unit in form and function and size. In an apple tree, some cells manufacture food, some cells store food, some cells transport water or food while other cells function to give strength. Other cells have the sole function of dividing to produce new cells. Some of these cells are large, some are small, some are long and some are short.

A group similar shaped cells, all performing a similar function is called a tissue. An example of a tissue would be epidermal cells covering the surface of a leaf. Now a group of different tissues, each performing a different function but organized together to achieve one job in the plant is an organ. A leaf is an example of a plant organ. It is comprised of many different tissue types yet they are all working together to achieve one goal; the goal of photosynthesis.

Each mature plant contains billions of cells, each one of which is partially independent. These cells are minute and cannot be seen without the aid of a microscope. They range in size from 0.1 to 0.01 mm in diameter. Living cells are dynamic units maintained in equilibrium with their surroundings. They must expend energy every second they are alive in order to function properly and to keep alive.

The plant cell is surrounded by a cellulose non-living cell wall. Inside of the cell wall is found the living material called the protoplast. It is the protoplast which secretes the cell wall. The cell must maintain itself in an equilibrium or steady state in order to survive. This steady state is known as homeostasis. Homeostasis keeps an oxygen level in cell constant, the sugar level in the cell constant, the water level in the cell constant, and regulates many other substances within the cell. Obviously when homeostosis breaks down, the cell cannot live very long. So the two most important prerequisite to life are homeostasis and a source of energy. When either of these fails the cell will soon die.

In plant cells many different kinds of metabolic processes are going on. These processes occur within discrete organized structures called organelles. Each organelle is surrounded by a membrane and it performs a specific function. Turn to diagram 3.1 which is a diagram of a generalized plant cell.

We will now discuss some of the major plant cell organelles and their function as well as some other important parts of the cell. Most of these structures are diagramed for you in diagram 3.1 but your book contains larger more detailed microphotographs of these structures. I want to suggest that after having gone through this tape, that you review these photographs in your text.

The cells of higher plants contain a nucleus. This nucleus is a small spherical structure surrounded by its own membrane called the nuclear membrane. Inside of the nucleus we find a gelatinous liquid called the nuclear-sap. It also contains one or more small spherical bodies called nucleoli. The nucleoli are composed of ribosomal RNA and proteins. Suspended in the nuclear sap is a network of thread-like genetic material called Chromatin. This Chromatin contains DNA coding which makes up the genes. When the process of cell division begins the chromatin becomes short and thick into structures which are called chromosomes.

Now let's turn our attention to the cell body which lies outside the nucleus.

The plant cell is enclosed by a non-living cellulose structure called the cell wall. It is produced by the living part of the cell called the protoplast. The cell wall which is formed during the early stages of cell growth is called the primary cell wall. It is composed of layers of cellulose fibers. It is thin and elastic and completely permeable to water and less permeable to other compounds. This primary cell wall is streached and kept in place by the pressure produced against it by the protoplasm. This pressure is called turgor pressure and the process is called turgidity. Most leaf tissues and some root tissues possess only primary cell walls and it is turgor pressure which keeps them rigid.

Other plant cells form what is known as a secondary cell wall. It is formed on the inside of the primary cell wall as certain cells become more mature. This secretion of a secondary cell wall is

called lignification because a substance called lignin is deposited on the inside of the primary cell wall. When lignification is complete, the cell wall becomes impermeable to water and other substances, so that those substances are unable to enter or leave the cell. These lignified cells slowly die. Lignified cells are rigid and strong. Thus they become mechanical support for the plant. Lignified cells are hollow tubes and when placed end to end they form the primary Vascular system of plants. The Vascular system is the system in plants which transports water and sugar through the plant body.

A plant cell with only a thin primary cell wall can continue to grow and expand by dissolving away part of the cell wall during the growth phase and then rebuilding it after growth has stopped. These cells can also divide into daughter cells when necessary. Plant cells with lignified secondary cell walls cannot grow nor can they divide.

Now let's look at the problem of holding cells together. In your body the cells have no cell wall, they are usually soft and are held together by connective tissue. In the plant body the cells are like bricks or concrete blocks and need a morter to hold them together. This morter is called the middle lamella. It is found between two adjacent cell walls. It is made of a flexable substance called pectin. In many cells small pores or pits exist across cell walls and act to connect the protoplasm of one cell with the protoplasm of an adjacent cell. These pores are called plasmodesmata.

We are now going to look at some of the more important cell organelles found in the cell. The protoplast has been defined as the entire living part of a cell. The protoplast consists of a nucleus. It also consists of a cytoplasm which is the living part of the cell outside of the nucleus.

The largest organelle in the cytoplasm is the Endoplasmic Reticulum. This structure is tube-like in shape and extends throughout the entire cytoplasm. It is also connected to the nuclear membrane. It transports cell products and has the organelle called the ribosome attached to it.

The ribosomes are small dense globular particles which are attached to the membrane of the endoplasmic reticulum. The synthesis of proteins, including enzymes, takes place on these particles.

Another important cellular organelle is the mitochondria. See if you can locate a mitochondria in the drawing at 3.1. You can see that it is a double membrane structure and the inner membrane has extentions into the center of the mitochondria. The mitochondria is the powerhouse for the cell. It acts to release energy from organic molecules in the cell.

Another cellular organelle which you can find in drawing 3.1 is the golgi body. It is made of a series of stacked double membranes which secrete a number of different substances. These substances are then collected into vacuoles. Golgi are always found in high concentration in cells which act to secrete such things as oils, resins and mucilagenous substances.

We now want to discuss an important structure called the vacuole. See if you can locate a vacuole in diagram 3.1. Vacuoles contain a liquid and are surrounded by a membrane called the tonoplast. Vacuoles have three main functions. First, they are sites for metabolic waste disposal. They collect and store a wide variety of waste substances produced by the cell. Also the vacuoles act to regulate water balance in the cell. Thirdly, the vacuole acts to produce pressure against the cell wall, creating turgidity which aids in keeping the cells' shape and form.

The outer most living boundry of the cytoplasm is the plasma membrane or semi-permeable membrane. This membrane functions as the door to the cell. This membrane maintains selective permeability with the environment. The plasma membrane usually connot be seen because it is pressed against the cell wall and held there by turgor pressure.

Another important cellular organelle is the chloroplast. The chloroplast contains the molecule chlorophyll, and, of course, chlorophyll is the site of photosynthesis. Will you locate a chloroplast in diagram 3.1. You will note that the chloroplast is disk-shaped. Inside a chloroplast are stacked layers called grana which contain the chlorophyll molecule. Chlorophyll would be found only in the green cells of the plant where photosynthesis is carried on.

The last organelle we want to discuss is the Spindle Fiber. This organelle is made up of small tubes called micro-tubules. It is found in the cytoplasm and functions to aid the cell in the cell division process by pulling the chromosomes to daughter nuclei.

As our last major topic for this tape we want to look at cell organization and tissues types. Tissues have special functions in the plant body. Some tissues function to produce new cells through cell division. These tissues are called meristems. Other tissues function in synthesis of food, storage of food, conduction of water and sugars, and support.

Meristematic tissues are physiologically young and are capable of continual division. Meristematic tissue, embryonic tissue, is made up of unspecialized simple cells having thin primary cell walls, rather large nuclei and abundant cytoplasms. Their chief characteristic is their ability to divide. Through this ability they initiate the formation of other tissue types and also maintain themselves.

One class of meristems is called apical meristems. They are found at the tips of shoots andat the tips of roots. They cause the stems and roots to grow longer. In other words a tree or bush gets taller and its roots get longer due to the production of tissues from apical meristems. These tissues produced by the apical meristems are called primary tissues.

The second most important meristematic tissue is the lateral meristem called the cambium. It is found only in dicotoledons and located just under the bark of the stem and roots. Cells produced by this meristem cause the plant to increase in circumference, producing tissues which are called secondary growth or secondary wood. It is the activity of the cambium which causes annual rings to be produced in stems and roots.

A very special meristem is found at the nodes of grass and some other monocotyledons. This meristem is called the intercalary meristem. It causes the elongation of internodes and leaves in these

plants. It is the intercalary meristem which allows our lawn grasses to continue to grow even after repeated mowing. By the way, be sure to look at diagram 3.2 and locate the meristematic cell.

The most simple cell type produced by the meristem is called a Parenchyma cell. Please locate a parenchyma cell in diagram 3.2. Parenchyma cells are thin walled and have a large central vacuole which causes high turgor pressure in these cells. They may be of primary or secondary origin and they usually cannot divide. They are capable of rapid expansion in size as they fill with fluid and thus they make up the majority of cells found in fruits such as apples and peaches. Parenchyma cells occur in all areas of the plant such as stems, leaves, flower parts, seeds and fruit. The plant epidermis is composed of parenchyma cells. Since these cells retain the latent ability to divide, they play an important role in healing and curing of wounds through the formation of callus tissue.

A slightly more advanced type of cell than the parenchyma cell is the collenchyma cell. They are actually a modification of parenchyma cells. A collenchyma cell can be seen in drawing 3.2. You will notice the main differences between these two cell types is that the collenchyma cell is more elongated and that it has secondary wall thickenings in the corner of the cell. Both of these changes give the collenchyma cell considerable more strength than is found in the parenchyma cell. Consequently, these cells lend mechnical support to the young plant, yet allow it to bend somewhat under wind stress. Collenchyma cells are living at maturity, have a high water content, and a large central vacuole. Collenchyma cells occur in the midrib and veins of leaves

and also the petioles of leaves.

The third type of cell produced by the meristems of plants is the sclerenchyma cell. Please locate a sclerenchyma cell in diagram 3.2. Sclerenchyma cells can develop directly from the cambium or they can develop from modifications of the parenchyma or collenchyma cells. The chief characteristic of sclerenchyma cells is their possession of a thick liquified secondary cell wall which makes them very strong and rigid, but brings about the death of the cell at maturity. Sclerenchyma cell in the form of fiber cells hold stems erect and enable them to withstand stresses and hold up under large loads of flowers and fruits. Another type of sclerenchyma cell is the sclereid. It is found mostly in fruits. The outer coat of nuts and seed coverings such as the peach seed is made-up of sclereid cells.

The final tissue type we want to discuss is the conducting tissues of the plant. Just as your body has a circulatory system which moves blood rapidly throughout your body, so the higher plant also has a circulatory system. It is frequently called the vascular system or the stele. This tissue is made up of much elongated cells called the xylem and phloem. See if you can locate the xylem and phloem cells in diagram 3.2. Xylem tissue normally conducts water and minerals in solution from the roots upward, whereas the phloem tissue conducts food (sugars) in solution from the point of synthesis to various areas of the plant. While several types of Xylem cells are found in plants, the most important type is the tracheid. It is very elongate cell and has heavy secondary cell walls with tapered ends. The walls of Tracheids have various types of pits or openings which permit easy

diffusion of water and minerals into adjacent cells. Frequently we find Tracheids butted together end-to-end forming not a single cell but a continuous tube through which water and minerals may move rapidly. These groups of long tubes are called vessels.

Sieve cells are the main component of phloem. They are elongated slender cells with thin non-liquified cell walls. Will you locate the drawing of a sieve cell in diagram 3.2. One or more small slender companion cells are living and in some way seem to be associated with the activities of the sieve cell. Phloem cells are alive at maturity but they usually die and function as a conducting tissue for usually one season only.

This is the end of Unit 3. Please turn off your tape recorder and rewind the tape.

HORTICULTURE I

UNIT 3

THE PLANT CELL

Educational Objectives

1. To know the three parts of the cell theory.
2. To be able to define a tissue; an organ and an organ system.
3. To be able to identify the following cell organelles, know their functi[illegible]nd location in the cell.

   a. **Nucleus**
      Nuclear Membrane
      Nucleolus
      Chromosomes or Chromatin
      Nuclear Sap

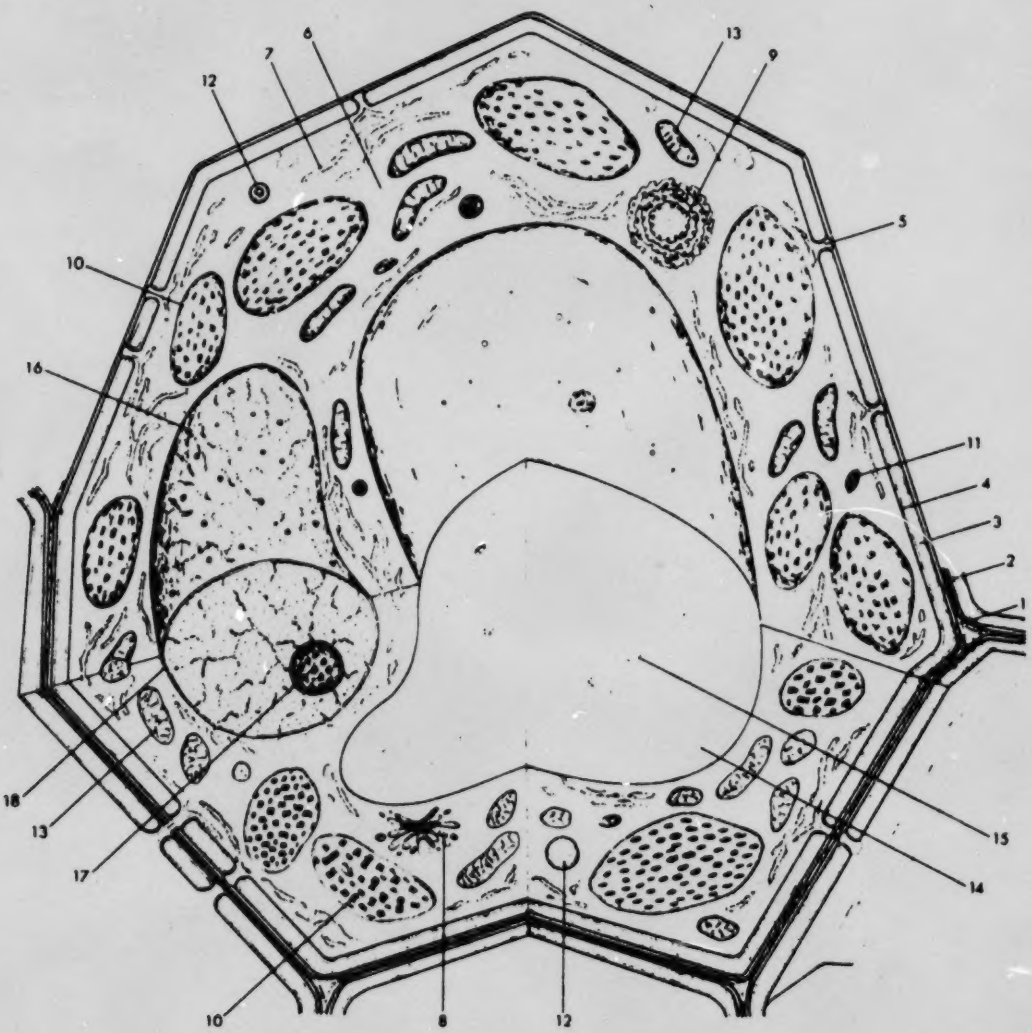
   b. **Cytoplasm**
      Endoplasmic Reticulum
      Ribosome
      Mitochondria
      Golgi Body
      Central Vacuole
      Cell Membrane (semi-permeable)
      Chloroplasts
      Spindle Fibers
      Primary Cell Wall
      Secondary Cell Wall
      Lignin
      Middle Lamella
      Pectates
      Plasmodesmata

4. To know how a cell enlarges and how a cell differentiates.
5. To know that a plant may grow by cell division or by cell enlargement.
6. To know that plant tissues are specialized for:
   a. Growth
   b. Synthesis of Food
   c. Storage of Food
   d. Conduction of Water, Mineral Elements, and Support.
7. To know that the three basic classes of permanent cell types are:
   a. Parenchyma
   b. Collenchyma
   c. Sclerenchyma
   d. Conductive Cells (Tracheids, Sieve and Companion Cells)
8. To know where meristems are located and their function.

UNIT 3

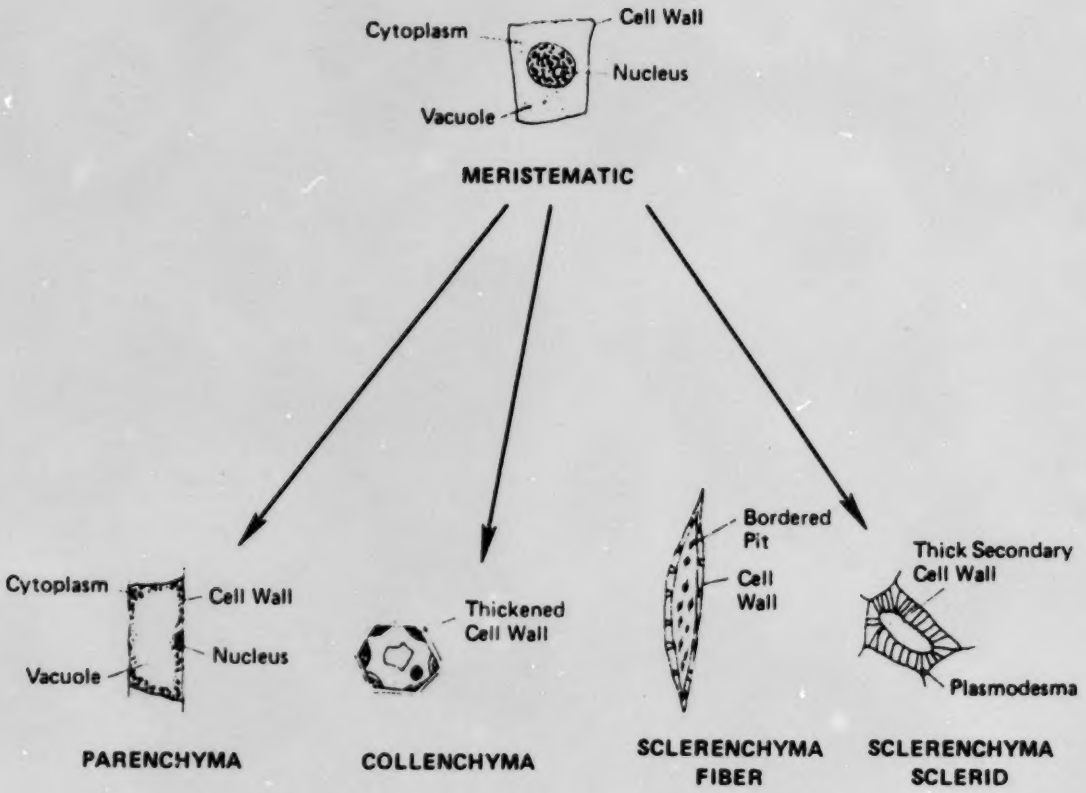
THE PLANT CELL

3.1 PLANT CELL

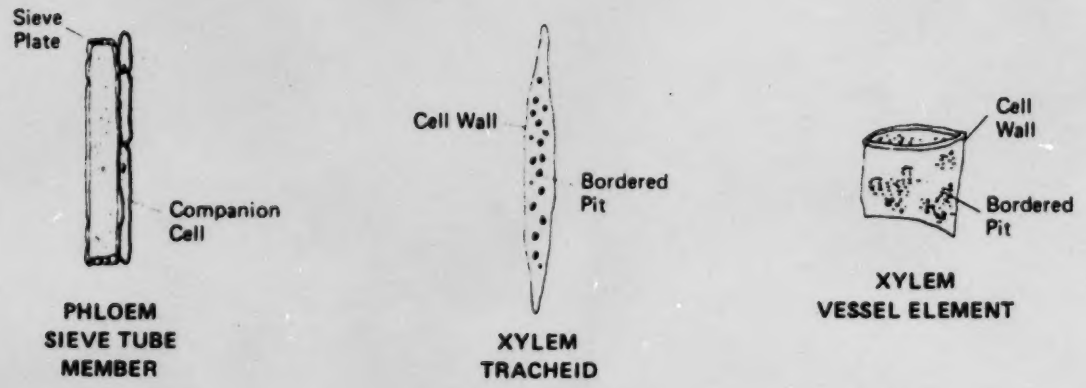


1. Middle lamella
2. Primary cell wall
3. Secondary cell wall
4. Cell membrane
5. Pit
6. Cytoplasm
7. Endoplasmic reticulum
8. Golgi body (section)
9. Golgi body
10. Chloroplast
11. Starch grain
12. Carotene chromoplast
13. Mitochondria
14. Vacuole
15. Crystal
16. Nucleus
17. Nucleolus
18. Nuclear membrane

3.2 PLANT TISSUE TYPES



CONDUCTIVE OR VASCULAR TISSUES



GLOSSARY: UNIT THREE

1. Cellulose: The chief constituent of the cell wall in all green plants; an ensoluble complex carbohydrate formed of microfibrils of glucose molecules.

2. Chromosomes: One of the bodies in a cell nucleus along which the genes are located; visualized a threads or nodes of chromatin, which appear in a contracted form during mitosis or meriosis.

3. Collenchyma cell: A class of plant cells which remain alive at maturity, develop elongated shapes, and deposit secondary cell walls in the corners of the cell.

4. Higher Plants: Plants which reproduce by seeds and have a vascular system.

5. Metabolic: The sum of all the chemical reactions occuring within a cell organism.

6. Organelle: A formed body in the cytoplasm of a cell.

7. Parenchyma cell: A class of cells composed of living, thin walled, randomly arranged cells with large vacuoles; usually photosynthetic or storage tissue.

8. Photosythesis: The sythesis of organic compounds from carbon dioxide and water in the presence of chlorophyll, using light energy.

9. Resins: A class of compounds found in some plants that are thick and sticky. Usually yellow or brown in color.

10. Sclerenchyma cell: A class of cells having elongated cell walls with a heavy secondary cell wall; usually vascular or support tissue.

INTRODUCTORY HORTICULTURE
UNIT FIVE SCRIPT
COMPLEX COMPOUNDS

In our last tape, we talked about some basic chemistry of living things. Today we will go into a little more detail about the chemical compounds found in cells, to further extend our understanding of this basic aspect of life. Let's first discuss the chemical properties of cells.

In our last unit we found that all matter, organic and inorganic, is made up of elements. The smallest possible unit of any element that retains the element's properties is an atom. Atoms, however, are never found singly in nature, except in the inert gases such as neon and helium. They are always combined with other atoms, of their own kind or other kinds, to produce molecules.

Man has found 92 different elements in nature and has been able to produce numerous others synthetically. It is very interesting that out of these 92 naturally occurring elements, only four appear to any great extent in living cells. These four--hydrogen, oxygen, carbon, and nitrogen--make up 99 percent of all protoplasm. As we shall soon see, the variety of molecules in living systems developed from just these four elements is utterly incredible.

Turn in the lab manual to the molecular table in Section 5.1. (PAUSE 5 SEC.) Note the symbols for hydrogen, oxygen, carbon and nitrogen. This first horizontal row is labeled "Elements." Now look at the next row down, labeled "Primary Molecules." The most important primary molecule in all living systems is water.

Hydrogen is one of the most chemically active of the four basic elements. When it is combined with oxygen to produce water, two hydrogen atoms bond with one oxygen atom to produce each molecule of water, as

indicated in the formula H_2O. Oxygen has two electrons in its inner shell and six electrons in its outer shell. Therefore, as we learned in the previous unit, oxygen needs two electrons to fill its outer shell and become electrically neutral. Hydrogen, on the other hand, has only one electron ring, and this ring can hold only two electrons. Since it already has one, it needs only one more to become electrically neutral. So hydrogen bonds only once. In the formation of a water molecule, the oxygen atom shares two electrons in a covalent bond with each hydrogen atom. Thus the oxygen has its two needed electrons, and the hydrogen atoms have their one each, and all three are chemically stable.

There are two other primary molecules which are important in living systems, both of which use hydrogen to complete their outer shells. In the space below the element carbon, you can see the formula for methane--CH_4. (REPEAT FORMULA) This molecule has a central carbon atom with four hydrogen atoms bonded to it. Remember, the carbon atom has four electrons in its outer shell. By bonding with four hydrogen atoms, it acquires their four additional electrons. Meanwhile each of the hydrogen atoms acquires one of the four electrons of the carbon atom, so all the atoms have complete outer shells.

Now under the element nitrogen you can see the formula for ammonia--NH_3. Ammonia is composed of nitrogen and hydrogen. Please turn back to the periodic chart in Unit 4, and see if you can determine the molecular configuration for ammonia. You will first need to know the number of electrons in orbit around the nitrogen atom. From this determine the number of hydrogen atoms that nitrogen would need to give its outer shell a full eight electrons. Stop the tape and do this now. (PAUSE 5 SEC.)

It is from these key molecules--water, methane and ammonia--that almost all organic compounds are formed. Because of their importance we

want to pause briefly to discuss some of the vital properties peculiar to each of these molecules.

Water is the best known solvent. It dissolves more substances than any other liquid, making it an ideal substance in which chemical reactions can occur.

Secondly, we must remember that water is found abundantly on earth and forms a valuable source of oxygen and hydrogen for living systems. Thus, the oxygen we breathe originated with water, and the hydrogen in all carbohydrates originated with water.

Methane, as we have indicated, is a carbon atom bonded to four hydrogen atoms. Methane's chief property is its ability to lose one or more of its hydrogen atoms and in their place substitute the atoms of other elements. Chlorine, for example, can be substituted for one or more of the hydrogen atoms. Another vital property of methane is the ability of two or more methane molecules to unite in carbon-to-carbon bonds, thus forming long carbon chains or carbon rings. We will talk more about these important molecules later.

The third primary molecule we want to discuss is ammonia. Ammonia has a nitrogen atom at the center of a configuration. The nitrogen atom is bonded to three hydrogen atoms. An important characceristic of ammonia is its ability to lose a hydrogen atom and in its place bond with a carbon atom. This molecule of nitrogen with only two atoms of hydrogen attached (NH_2) is given a special name. It is called an amino group.

Look at the third row of the chart in your manual, labeled "Simple Organic Molecules." The compounds formed from these molecules are called

organic compounds because they all contain the element carbon. The five classes simple organic molecules are all formed from carbon in combination with the primary molecules--water, methane, and ammonia.

Please read these molecules as they are read to you. They are simple sugars, glycerin (SPELL), amino acids (SPELL), fatty acids (SPELL), and nitrogen bases (SPELL). These simple organic molecules are formed through synthesis reactions which require energy. We want to discuss each of these molecules briefly, indicating which of the basic molecules are used in its formation, what unique properties each one has, and how each is important in the life of the cell.

Sugars belong to a class of compounds called carbohydrates. These compounds contain only carbon, hydrogen and oxygen. Usually the ratio is one carbon atom to two hydrogen atoms to one oxygen atom. The carbon atoms are linked together in a carbon-to-carbon chain. The simple sugars are known as monosaccharides, and each molecule contains from two to ten carbon atoms. Figure 5.2 illustrates two (2) simple sugars. Simple sugars, or monosaccharides, are very widespread in living materials, and are chemically active. They form the basic building blocks for the synthesis of many other, more complex organic substances. When they are broken down, they provide energy. Please turn off the tape and read the discussion of carbohydrates in Section 5.2. (PAUSE 5 SECONDS)

Figure 5.3 shows the chemical structure of a molecule of glycerin. Notice that glycerin is also composed of carbon, hydrogen, and oxygen. Its formula is $C_3H_8O_3$. Notice how the three carbons are linked together in a chain.

The fatty acids form a large class of compounds. Like the sugars and glycerin, the fatty acids contain only carbon, hydrogen, and oxygen. As you

can see in Figure 5.4, they too are composed of a carbon chain, which may vary in length from 2 to 20 carbon atoms as indicated by dots between the carbons. At the end of the chain two oxygen atoms are bonded to a carbon atom. One has a double bond with the carbon, while the other has one bond with the carbon and one bond with a hydrogen atom. This particular arrangement of atoms at the end of a carbon chain is given a specific name. It is called a carboxyl group (COOH). It is found in organic acids and in many other organic compounds.

With the fourth group of simple organic compounds, amino acids, we encounter for the first time molecules made up of four elements. Figure 5.5 illustrates the three units which combine to form an amino acid. Notice the amino group on the left side of the configuration. We have previously indicated that the amino group has nitrogen at the center, and is usually formed from an ammonia molecule by the removal of a hydrogen atom, changing NH_3 to NH_2. In place of this removed hydrogen atom, the amino group always has an attached carbon chain, at the end of which is a carboxyl group. This carbon chain can vary in length from one to many carbon atoms, and usually it is represented in molecular configurations by substituting the capital letter R, which represents collectively any of the carbon chain possibilities.

The fifth group of compounds in our basic organic molecule classification are the nitrogen bases. The nitrogen bases always have a ring configuration, with nitrogen and carbon forming the atoms of the ring. Figure 5.6 illustrates a nitrogen base. The peripheral bonded atoms are not shown, since they vary among the different compounds of this group.

There are five different nitrogen bases. They are adenine, thymine, cytosine, guinine, and uracil (SPELL). The peripheral bonded atoms are not shown.

Thus far we have dealt with three levels of complexity. The simplest level is the atom; the second level is the simple molecule; the third level consists of the basic organic molecules. Now we move on to the fourth level, the Complex Organic Molecules. Please look at the chart we have been constructing in Section 5.1 and let's review our progression. (PAUSE 5 SECONDS) Thus far, we have established that four elements are involved in most organic molecules. They are hydrogen, oxygen, nitrogen, and carbon. Secondly, atoms of these elements combine to form three simple molecules: water, methane, and ammonia. Thirdly, these three basic molecules combine in various ways to form the six simple organic molecules. They are the simple sugars, glycerin, fatty acids, amino acids, and nitrogen bases.

In the fourth row of the chart 5.1 labeled "Complex Organic Molecules", please list five types of molecules as I give them to you: polysaccharides (SPELL), Fats, proteins, nucleotides (SPELL), and nucleic acids (SPELL). (PAUSE 5 SECONDS)

Disaccharides are a chain of sugars. They are synthesized by the bonding of two simple sugar or monosaccharide units into a longer molecule, with the production of a molecule of free water, as shown in Figure 5.7. This process is called dehydration synthesis. (PAUSE 5 SECONDS) When more than three monosaccharides are joined, the resulting carbohydrate is a superlarge molecule called a polysaccharide. We are all familiar with some polysaccharides such as starch and cellulose.

The next group of complex organic molecules we will consider are the fats or lipids.

Fats are a source of concentrated energy and useful as building materials for more complex cellular structures. A fat molecule consists of one glycerin or glycerol molecule plus three fatty acid molecules. Various kinds of fatty

acids combining with glycerol result in chemically different fats. For example, if the fatty acids involved are made up of long carbon chains, the resultant fat will be a thick oily substance which will not flow easily, but if the fatty acids are short chains, the resultant fat will be a thin oily substance and therefore flow easily.

Figure 5.8 illustrates the bonding of one glycerol molecule and three fatty acid molecules. In the bonding of fatty acids and glycerine, we find that three water molecules are produced in the process, one molecule at each bond, again by the process of dehydration synthesis.

If we examine the fat molecule at 5.8 we can see that each fatty acid molecule has an entire ring of hydrogen atoms on each side of the molecule. Each carbon atom, with the exception of one making up the carboxyl ending, has at least two carbons bonded to it. This molecule has the maximum number of hydrogens bonded to it and we say that it is saturated with hydrogens and it is called a saturated fat.

Now let's look at the same fat molecule in diagram 5.9. You can see immediately that the peripheral ring of hydrogen atoms is broken and numerous hydrogens have been removed, one at each dotted circle. In order to achieve the required number of bondings for carbon, a double carbon bond is substituted for each two hydrogen atoms removed. This fat is called a polyunsaturated fat.

Many nutritional authorities believe that the human body may take saturated fats, which are acquired through ingestion of foods, and convert them into excessive quantities of serum cholesterol. This serum cholesterol can in turn be converted to plaque, a fatty deposit, which accumulates on the inside of large arteries where it retricts blood flow causing high blood pressure and brings on the ageing disease called arterosclerosis.

Polyunsaturated fats, on the other hand, seem to not be converted into cholesterol in our body and are therefore maybe helpful in lowering the serum cholesterol levels in the body.

Fats derived from animal tissues are heavy in saturated fats, while most fats derived from plants are lower in saturated fats and higher in polyunsaturated fats. Nutritional experts advise Americans to lower their total fat intake, and concentrate on using plant fats, such as safflower oil, corn oil or soybean oil in cooking and where ever fats are used in the diet.

In review, we want to note that lipids, or fats, are compounds containing carbon, hydrogen and oxygen. That when compared to carbohydrates, they always contain higher proportions of hydrogen and lower proportions of oxygen. Each fat molecule consists of one glycerine molecule bonded to three fatty acid molecules. A fatty acid is a molecule contains a central portion consisting of a carbon chain with peripheral bondings of hydrogens at the end of which we find a carboxyl ending. The carbon chains can vary from as few as three carbons to as many as 30 carbons. The shorter carbon chained fatty acids are classified as oils, while the longer carbon chained fatty acids are classified as greases or tallows.

Fats have a two-fold use in plant and animal bodies: ONE, fats are a source of concentrated energy. TWO, fats are used as building blocks for many complex cellular structures.

Fats can further be classified as saturated and polyunsaturated. Saturated fats contain a maximum number of peripheral bonded hydrogen atoms and are found in animal tissues. Polyunsaturated fats have numerous hydrogens removed which results in the double bonding of some of carbon atoms in the central carbon chain. Polyunsaturated fats are found mostly in plant fats and oils.

Proteins are the third group complex organic molecules. Proteins are difficult to discuss, because there are so many, many types of proteins and because they are among the largest of all molecules found in living materials. The enzymes, which control all chemical processes in cells, are all proteins. It is obvious that proteins form one of the most important groups of substances in cells.

Proteins are amino acids joined together. We have indicated that an amino acid is made up of an amino-group bonded to a carboxyl group, with a carbon chain in-between, which is usually shown in the structure as R. The R can stand for any of 25 carbon chains, which accounts for the 25 different amino acids found in nature. A tremendous number of amino acids can combine to form a single protein molecule.

And since the number of bonding possibilities is also huge, we are dealing with an almost infinite number of possible proteins. We might draw a parallel between the 25 amino acids and the 26 letters in our alphabet. We can visualize Webster's Unabridged Dictionary containing thousands of words, all combinations of the alphabet's 26 letters. In the same way, the 25 essential amino acids combine to produce thousands of different protein molecules.

However, practical considerations of easy spelling and pronunciation limit the length of words. Thirty-letter words are pretty awkward. In the formation of proteins, amino acids are not encumbered by such restrictions. In some proteins, one hundred thousand or more amino acids can bond to form a single molecule. The geometrical pattern and the relative size of such molecules stagger the imagination.

The bonding point between two amino acids is called a peptide bond. A water molecule is always produced by such a bond. The hydroxyl group is removed from a carboxyl group and the hydrogen is removed from the amino

group. This phenomenon is illustrated in Figure 5.10. (PAUSE 5 SECONDS) A simple protein made up of only two amino acids bonded together is called a dipeptide.

The fourth group of complex organic molecules to be discussed are the nucleotides. As the name implies, they are found in the cell nucleus. Nucleotides result from the bonding of three simple organic molecules into a single molecule. The three sub-molecules are a sugar, a phosphate, and a nitrogen base. Notice this is the first time we encounter an organic compound which is not made up only of carbon, hydrogen, oxygen and nitrogen. The additional element is a nucleotide is phosphorus. Figure 5.11 illustrates a typical nucleotide molecule. (PAUSE 5 SECONDS) You will notice that the sugar molecule involved in the nucleotide is a five-carbon sugar. All nucleotides are formed from one of two different five-carbon sugars. Figure 5.12 shows these two sugars. The one on the left is called ribose sugar and the one on the right is called deoxyribose sugar.

Nucleic acids are giant molecules made up of hundreds of thousands of different nucleotide molecules. Nucleotides containing ribose sugar can bond only with other nucleotides containing ribose sugar, and the same is true of nucleotides containing deoxyribose sugar; the two types cannot mix. Thus we end up with two distinct nucleic acids: ribonucleic acid and deoxyribonucleic acid. These acids are important in determining the hereditary pattern in each species and in each individual. They are usually abbreviated RNA and DNA. We will be talking about them in more detail in a subsequent unit.

Please review the chart which you have made in Section 5.1 showing the step-by-step building process of organic compounds. It is important that you know all of the basic elements and the organic molecules formed

from them, as they form the basis for study of cellular metabolism. If you do not completely understand the material thus far presented, please go back and review it at this time. (PAUSE 5 SECONDS)

As a final look at organic compounds we want to review the cellular utilization of carbohydrates, fats and proteins and indicate the caloric value of each when they are used as a source of energy in cells.

Carbohydrates are a basic source of energy for all living organisms. Simple sugars can easily be converted into energy by all cells. Starch is used by both plants and animals as a storage form of energy. It is almost completely inactive chemically and can be kept in reserve as a potential source of immediate energy for long periods of time. While animals use carbohydrates mainly as energy, plants can use carbohydrates not only for energy but they also use carbohydrates to form the basic skeleton system of the plant. They do this because they have the ability to synthesize cellulose from starch molecules. Cellulose is a long, water-insoluble fiber made up of many starch molecules meshed together. It is this cellulose which makes up the cell wall around plant cells. The trunk, branch, and leaves of a tree contain large quantities of cellulose which supports the plant and is, in effect, its skeleton system.

Carbohydrates, when used as energy, produce four calories of energy for each gram consumed. Carbohydrates are always the first priority molecules to be used as energy in a cell.

Fats can also be used as energy in a cell, and they are the second priority molecule for energy. Fats are a concentrated form of energy and yield nine calories of energy for each gram utilized by the cell for energy. Fats are also important in both plant and animals as building block molecules to synthesize many structural organelles inside of cells. For example, all

cell membranes contain lipids or fats as an integral part of their structure.

Proteins are used as a source of energy by cells only in emergency situations, when cellular carbohydrates and fats have both been exhausted. At this time they yield 4 calories of energy for each gram used. Proteins have a variety of functions in living cells. We must remember that while the plant body is mostly carbohydrate, the animal body is mostly protein. Our bodies are made-up of muscle, blood, bone, brain, and skin tissues; all of which contain large quantities of proteins. Furthermore, all cellular enzymes are protein and body fluid buffers contain proteinatious material.

The nucleic acids, which are synthesized from nucleotides, are restricted to the cellular nucleus and are not used as energy but for the chromosomes and genes of the cell. This hereditary material functions to control all cellular activity and must be transmitted through the sex cells to the next generation.

In closing our discussion about the chemistry of cells, it is important that we mention two other substances found in living cells. These are trace elements and vitamins. The trace elements, or minerals as the name implies, are found in small amounts in protoplasm and are usually in the form of ions having an electrical charge. They help form a wide variety of compounds which function in many cellular activities. Such minerals as calcium, chlorine, magnesium and iron play important roles in many cellular molecules and in many cellular reactions.

Vitamins, like trace elements, are required in small quantities in living cells. But unlike trace elements, they are not ionic. Plants can manufacture all the vitamins they need, but most animals cannot. Therefore, animals depend on plants for certain vitamins. Most vitamins become part of the enzyme molecules functioning to activate these molecules inside of cells.

This is the end of Unit 5. Please turn off your tape recorders.

HORTICULTURE I

UNIT 5

COMPLEX COMPOUNDS

Educational Objectives

1. List, define or describe for carbohydrates, fats or lipids and proteins the following:
   a. The elements present in each and the basic proportion of C, H, and O in carbohydrates and fats.
   b. Dehydration synthesis and hydrolysis decomposition as the processes which synthesize and decompose these molecules.
   c. The functions of each within cells or organisms, i.e., provides energy, becomes a structural component or acts as an enzyme.
   d. The fate of excess quantities of each of these molecules in plant.
   e. The caloric value of each.
   f. Describe lab procedures that would be used to test an unknown for the presence of each.
2. Distinguish between carbohydrates of various sizes as monosaccharides, disaccharides, and polysaccharides and give an example of each. (Relate each size to rate of reaction).
3. Describe the synthesis of fats from fatty acids and glycerol and indicate the relationship between viscosity of the fat and the length of the fatty acids used in its synthesis.
4. Describe the difference between saturated fats and polyunsaturated fats.
5. Know that proteins are synthesized by combining amino acids; that some 20 different amino acids are used.
6. Relate specificity of proteins, particularly those which act as enzymes, to the kind and arrangement of amino acids present.
7. Describe the basic function of vitamins in living organisms.
8. Describe the basic function of mineral elements required in most plants.
9. Define a nucleotide as a molecule composed of three parts:
   a. a 5-carbon sugar
   b. a phosphate group
   c. a nitrogenous base
10. Know that the 5-carbon sugar may be either ribose or deoxyribose sugar.
11. Know that the nitrogenous base may be either adenine, thymine, cytosine, guanine or uracil.
12. Know that nucleic acids of two types are formed by combining large numbers of nucleotides all of which have the same 5-carbon sugar.
13. Differentiate between deoxyribose nucleic acid-DNA and ribose nucleic acid-RNA.
14. Know that nucleotides and nucleic acids are synthesized in cells.

UNIT 5

COMPLEX COMPOUNDS

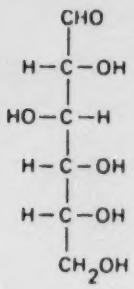
This unit is designed to advance the student's knowledge of the cell as the unit of life by acquainting him with some of the cell's more important chemical compounds. Review the objectives for this unit.

5.1: MOLECULAR TABLE

Elements	Hydrogen, H		
	Nitrogen, N	Oxygen, O	Carbon, C
Primary Molecules	NH_3	H_2O	CH_4
Simple Organic Molecules	Simple Sugars, Glycerin, Amino Acids, Fatty Acids, Nitrogen Bases		
Complex Organic Molecules	Disaccharides Nucleotides	Polysaccharides, Fats, Proteins Nucleic Acids, Nucleotides	

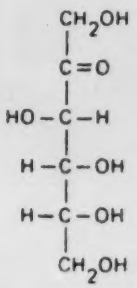
5:2 CARBOHYDRATES

Carbohydrates are chemical compounds usually containing carbon, hydrogen and oxygen in a 1:2:1 ratio. The ending "ose" is used to indicate a sugar and a prefix is added to indicate the number of carbon atoms in a sugar. For example a hexose ($C_6H_{12}O_6$) is a six carbon sugar and a pentose ($C_5H_{10}O_5$) is a five carbon sugar.



Glucose

A Hexose Monosaccharide

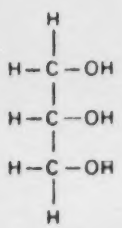


Fructose

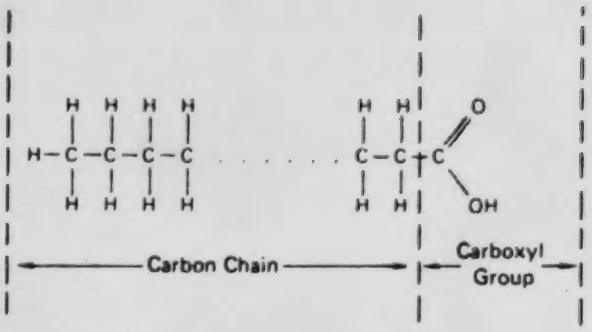
A Hexose Monosaccharide

The above examples are simple sugars. They are called monosaccharides. Monosaccharides may be synthesized into larger sugar molecules by uniting two or more monosaccharides together to form such sugars as disaccharides and trisaccharides. At the bonding of two monosaccharide units a water molecule is removed. Compounds containing large numbers of monosaccharide units bonded together are known collectively as polysaccharides.

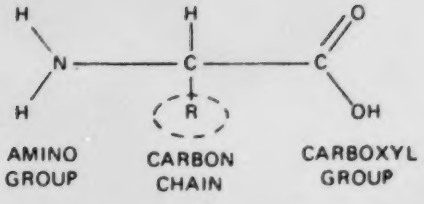
5.3: GLYCERIN (GLYCEROL)



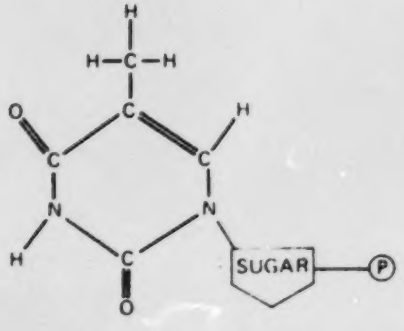
5.4: FATTY ACID



5.5: AMINO ACID

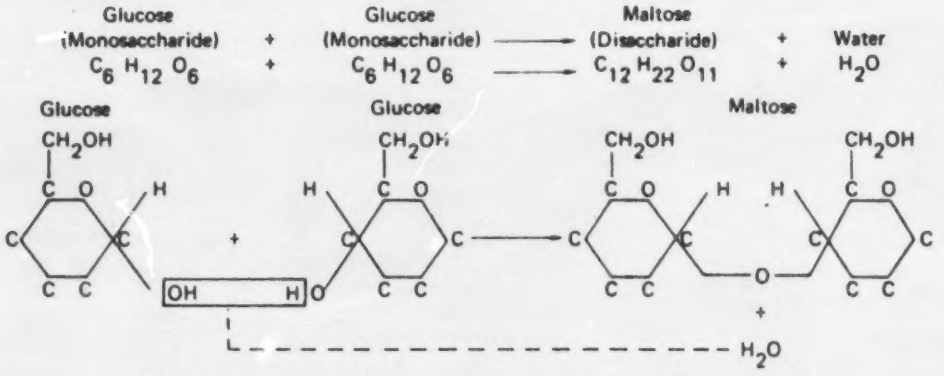


5.6: THE NITROGEN BASE THYMINE



Note: The sugar molecule and the phosphate group shown in lighter line are not an integral part of the nitrogen base but when present combine with the nitrogen base to form a nucleotide unit.

5.7: SYNTHESIS OF DISACCHARIDE CARBOHYDRATES

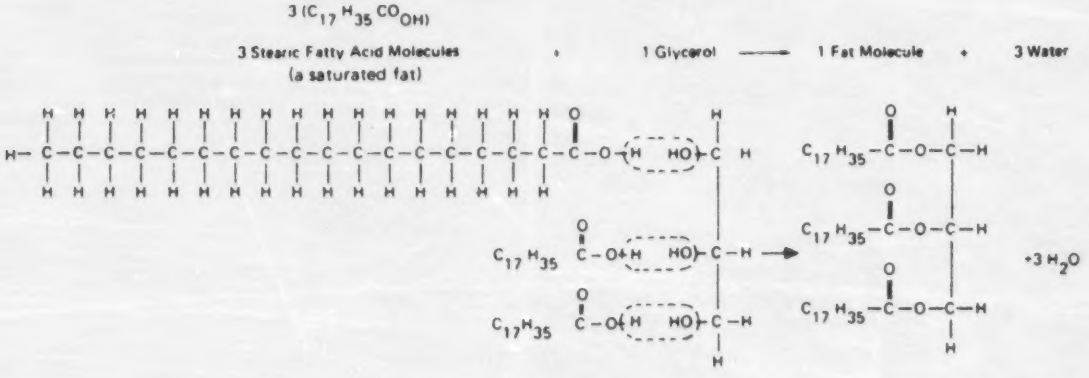


Glucose + Fructose → Sucrose + Water
$C_6H_{12}O_6$ + $C_6H_{12}O_6$ → $C_{12}H_{22}O_{11}$ + H_2O

Glucose + Galactose → Lactose + Water
$C_6H_{12}O_6$ + $C_6H_{12}O_6$ → $C_{12}H_{22}O_{11}$ + H_2O

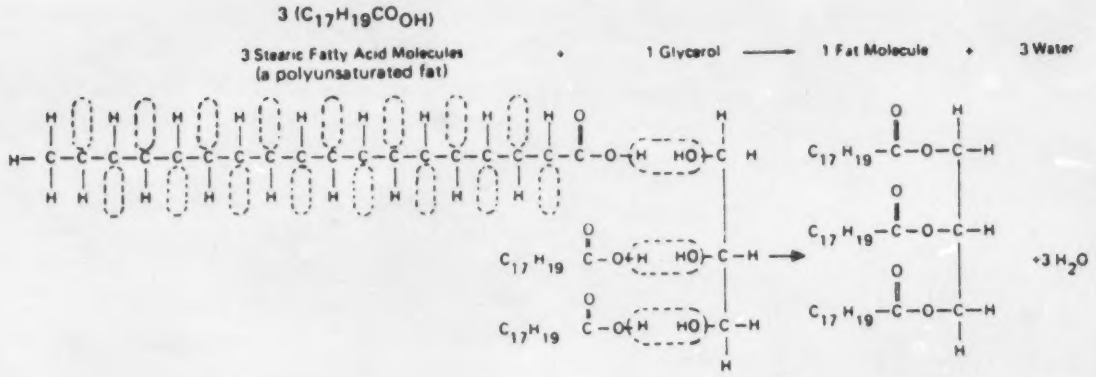
Note: Two sugar molecules may have the same molecular weight, but different atomic arrangement, producing a different molecule which results in two distinct sugars, each with distinct properties. Such molecules are called isomers.

5.8: SYNTHESIS OF SATURATED FATS

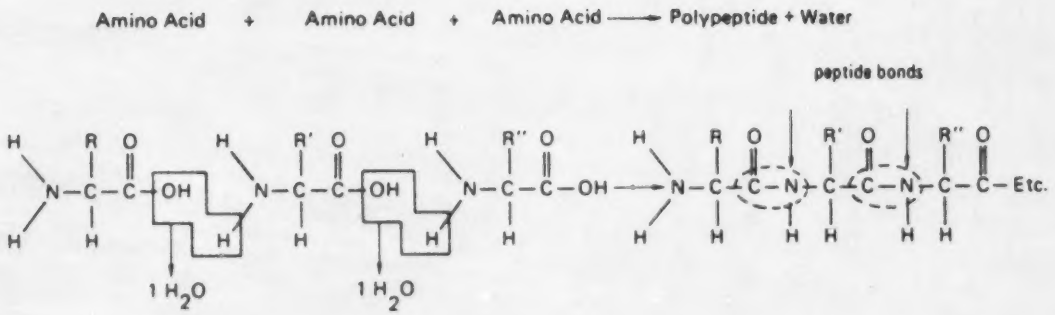


(Notice the carboxyl group at the right end of each fatty acid molecule.)

5.9: SYNTHESIS OF POLYUNSATURATED FATS

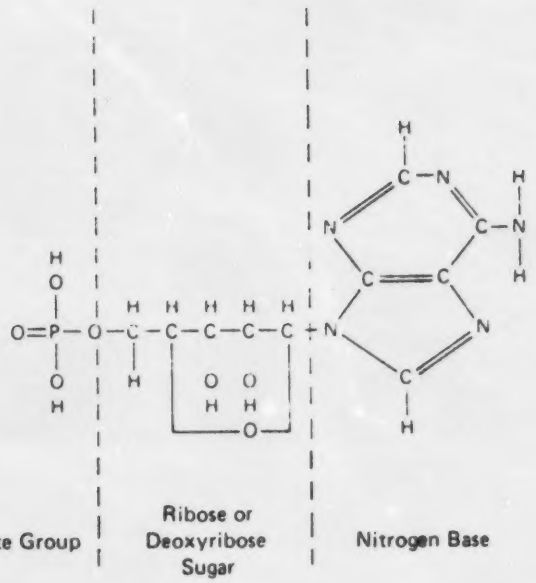


5.10: SYNTHESIS OF PROTEINS

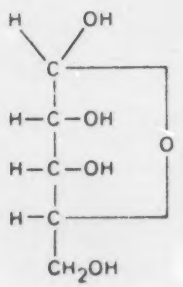


(Can you locate the carboxyl group at the end of each amino acid molecule?)

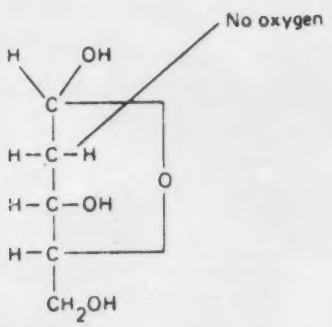
5.11: NUCLEOTIDE MOLECULE



5.12: EXAMPLES OF FIVE-CARBON NUCLEOTIDE SUGARS



Ribose



Deoxyribose

GLOSSARY: UNIT FIVE

1. Artheroscherosis: The process of laying down deposits of fatty substances in the arteries of man.

2. Buffers: A complex of chemicals found in the cell and fluid of an organism which prevents changes in pH.

3. Cellulose: The chief constituent of the cell wall in all green plants; an insoluble complex carbohydrate formed of microfibrils of glucose molecules.

4. Cholestrole: A steroid fat used by the body to sythesize hormones; frequently deposited along the walls of arteries causing artherosclerosis.

5. Chromosomes: One of the bodies in a cell nucleus along with the genes are located; visualized as threads or nodes of chromatin, which appear in a contracted form during mitosis or meiosis.

6. Deoxyribonucleic acid: (DNA) The carrier of genetic information in cells, composed of two comptement any chains of nucleotides, capable of self-replicating as well as coding for RNA synthesis.

7. Gene: A unit of heredity in the chromosome; a sequence of nucleotides in a DNA molecules that codes for a protein.

8. Polyunsaturated fat: A fat in which some of hydrogen atoms on the fatty acid chain have been removed. Found chiefly in plant fats.

9. Protoplasm: All the living contents of a cell. Usually divided into the nucleus and cytoplasm.

10. Saturated fat: A fat in which all of the carbon atoms in the fatty acid chain have been bonded to a maxium number of hydrogen atoms. Found chiefly in animal fats.

11. Starch: A class of complex, insoluble carbohydrates, the chief food-storage substance of plants; composed of several hundred sugar units.

INTRODUCTORY HORTICULTURE

UNIT NINE SCRIPT

VEGETATIVE GROWTH AND DEVELOPMENT

Most seed bearing plants are composed of a vertical cylindrical axis which has a variety and complexity of lateral appendages. The above ground section of this axis is the stem and the below ground axis is the root system. Thus roots, stems and leaves are the vegetative parts of the plant.

Let's review just a bit. Monocot plants develop a plant body only from root and shoot apical meristems. This is called the primary tissue and monocots contain only primary tissue. Dicot plants not only have primary tissue but they also have secondary tissues which develops from the cambium. The cambium is a layer of meristematic tissue which lies just under the bark and which produces cells which cause the stems and roots of the plant to increase in circumference. Diagram 5.1 in your workbook shows the primary plant body of a dicot plant.

We now want to take a closer look at the plant root system. Roots function in three ways. They anchor the plant, absorb water and minerals in solution, and the root system often stores food. Roots are usually more simple in structure than stems for they are without external buds, leaves, nodes and internodes. Also they do not have flowers and fruits. Most roots are found below the soil but in some plants roots can be found above the soil. Adventituous prop roots of corn which extend from the stem to the soil give added support to the plant. Some plants have aerial roots which anchor the plant or attach it to a substrate. An Ivy is an example of such a plant. Roots do have two structures which stems do not have. Roots have root hairs and roots have root caps.

We now want to look at the kinds of roots and their functions. Fig. 5.2 in your workbook illustrates the three basic root types. At "A" we can see a taproot. It is found in large trees, in shrubs such as an Oak. You will notice the labels primary root and secondary root. The primary root develops from the radicle in the seed embryo while the secondary root (sometimes called a lateral root) branches off from the primary root and grows somewhat horizontally.

A tap root is a root system in which the primary root becomes dominant and enlarges producing small secondary roots. At "B" in the diagram you can see a carrot root, an example of a storage taproot. At 5.2 diagram "C" you can see a fibrous root system. In a plant such as a strawberry which has a fibrous root system, the primary root does not grow extensively but the lateral and secondary roots grow rapidly and branch and divide many times.

Roots are ideally suited for absorption since their irregular arrangement of complex branching presents a very large surface area in contact with the soil. Much of this surface area is derived from numerous root hairs associated with areas of new growth. Root hairs are transitory and die as they get older and are found farther back on the maturing root. Some young epidermal root cells can also absorb water. A special class of fungi called mycorrhiza, are found in contact with many roots. These fungi organisms increase absorption of water and nutrients by roots of many horticultural plants especially in areas of the root system that are mature and not growing and thus have few root hairs.

The young growing root is divided into three regions. Diagram 5.3 illustrates the three regions of a growing root. The lower most region is called the apex. It contains the root cap which is made up of new cells and protects the root apex from mechanical injuring and acts as a sort of lubricant as the

root pushes through the soil. The root apex also contains the root meristem and through cell division produces new young cells that will form new tissues. They maintain themselves through cell division. In the zone of elongation the cells expand and increase in size from tiny embryonic cells produced in the root apex to large mature cells. This increase in size is mostly in length rather than in width. This produces cells which are long and rectangular in shape.

In the area of maturation the cells attain the state of physiological maturity and begin to function as mature cells. It is in this area of maturation that root hairs are produced.

We now are going to look at stems. The horticulturalist frequently uses the term "shoot". A shoot is composed of a stem and leaves that is rapidly growing. Botanists believe that stems are the most complicated and the oldest evolved parts of the plant. Roots evolved from the stem and likewise did the leaves and the flowers. The stem functions to support the leaves and the flowers; it also conducts water and nutrients absorbed by the roots to the leaves. Some stems contain chlorophyll and thus have limited food-producing ability; mostly when young. Stems also store food with some stems becoming thick and fleshy with stored food and liquid, as we find in the cactus family.

Stems of most plants grow in length as well as in diameter. Growth in length is initiated by cells of the apical meristem. The apical meristem is located at the tip of branches and is covered and protected by young embryonic leaves during the growing season, or it is protected by several layers of bud scales during the dormant season. Many plants not only grow

in length or height but they also grow in girth or diameter. This growth in diameter is due to the production of cells from the lateral meristem, called the cambium. The cambium is a thin cell layer located just under the bark and as it produces cells the plants' trunk and branches increase in girth. This increase in girth during each growing season causes trees to have annual rings. By counting annual rings we can determine the age of a tree.

Let's look at the various tissues found in a cross section of a monocot stem as illustrated at diagram 5.4. Monocots do not have a cambium layer and cannot increase in girth. Also the conductive tissue (xylem and phloem) is arranged in structures called vascular bundles. These vascular bundles are scattered at random throughout the stem as diagram 5.4 shows.

Diagram 5.5 is a cross section of a woody dicot stem. It is called a woody stem because it increases in girth every year and lays down an annual ring. All the tissue produced during the first years' growth is produced by the apical meristem and is called primary xylem and primary phloem. Xylem and Phloem layers produced during subsequent years growth are produced by the cambium and are called secondary xylem and secondary phloem. Notice that the plant diagrammed at 5.5 has three annual rings. Also all the phloem is located outside the vascular cambium and the xylem is located inside the vascular cambium.

An appendage to stems are buds. Buds are embryonic stems which can remain dormant for indefinite periods of time but which can also grow actively producing a new branch and leaves or flowers. Diagram 5.6 demonstrates some of the various types of buds. The terminal buds contain at their center apical meristems while the lateral buds contain at their centers lateral meristems.

It was previously stated in this tape that terminal and lateral buds are protected by either young immature leaves or overlapping bud scales.

Stems have a wide variety of modifications. Some stems are modified to grow below ground and have below ground modifications. Turn to diagram 5.7 which diagrams some of the more common above ground modifications. Above ground modifications include climbing stems and succulent stems which store liquids. Some climbing stems support themselves by twisting around something while other climbing stems send out tendrils to grasp with. Other stem modification include runners. These runners or offsets produce new plants at their tips.

The major underground stem modifications are illustrated at diagram 5.8. These include bulbs, corms, rhizomes, stolons, suckers, and tubers. A bulb is a short fleshy stem axis that has an immature flower or growing point at the center plus extensive overlayment of fleshy scales. The common onion is a good example of a bulb. A corm is the enlarged base of a stem portion of a bulb. This stem portion contains stored food material. The gladiolus is an example of a corm. The shizome is a specialized stem structure which grows horizontally on the soil surface. It can be distinguished from roots because it has nodes and internodes. A pachymorph rhizome is thick and fleshy like an Iris while a leptomorph rhizome is slender and long. An example of a leptomorph rhizome would be a lily-of-the-valley. Stolons are similar to rhizomes except that they grow under the soil surface in a horizontal fashion. A sucker is a shoot which arises from a root system of a plant. Raspberry plants frequently propagate by producing suckers.

As a final topic for this tape we want to discuss leaves. Most of the information on leaves has been presented in the unit on photosynthesis and in the unit on taxonomy. Botanists consider leaves as flattened or expanded parts of the stem. Many different tissue types are found in leaves. Leaves, however,are different than stems in that their growth and life is limited. All leaves grow for a while than stop growing and then eventually die. The design of the leaf serves to present a large surface area for absorption of light energy needed for photosynthesis. The two main functions of the leaf are food manufacture through photosynthesis and water loss through the process of transpiration.

This is the end of the tape nine. Please turn off your tape recorder.

HORTICULTURE I

UNIT 9

VEGETATIVE GROWTH AND DEVELOPMENT

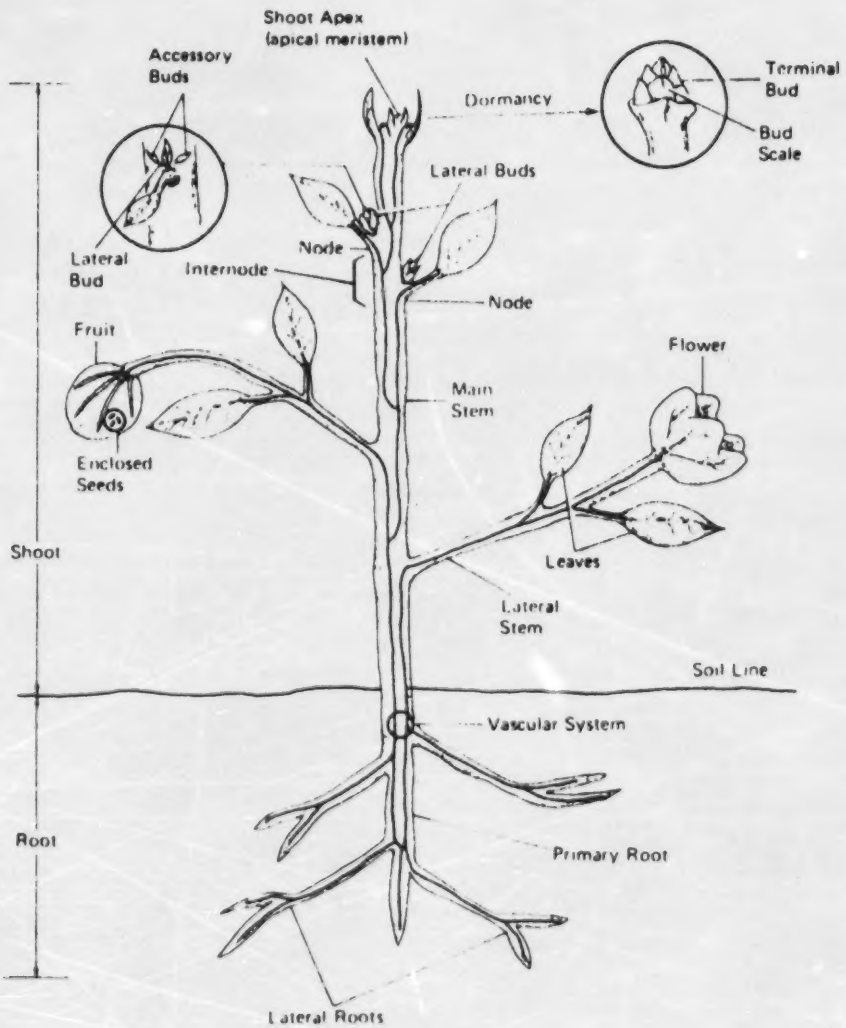
Educational Objectives

1. Roots:
   a. To know the functions of the root system
   b. To know the location of roots
   c. To know the difference between roots and stems
   d. To know the kinds of roots
   e. To know how a root grows and how root hairs form
   f. To know the function of root hairs
   g. To know how the root translocates minerals and water
2. Stems:
   a. To know that stem is the most basic part of the plant
   b. To know that stems are composed of nodes and internodes; apical buds, lateral buds and bear leaves and flowers
   c. To know the function of stems
   d. To know the various regions of the stem
   e. To know the various types of buds found on a stem
   f. To know the elementary facts of stem internal structure
   g. To distinguish the various forms of stem adaptation
3. Leaves:
   a. To know that leaves are lateral outgrowths of the stem that function in photosynthesis
   b. To know the morphology of a leaf (in unit on photosynthesis)
   c. To be able to classify leaves by veination and blade form (in unit on taxonomy)
   d. To be able to classify the various types of leaf arrangement on the stem (phyllotaxy) (in unit on taxonomy)

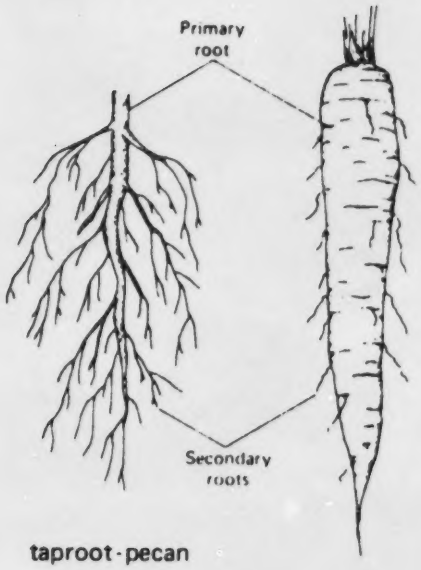
UNIT 9

VEGETATIVE GROWTH AND DEVELOPMENT

9.1: A GENERALIZED DIAGRAM OF A VASCULAR PLANT BODY



9.2: ROOT SYSTEMS

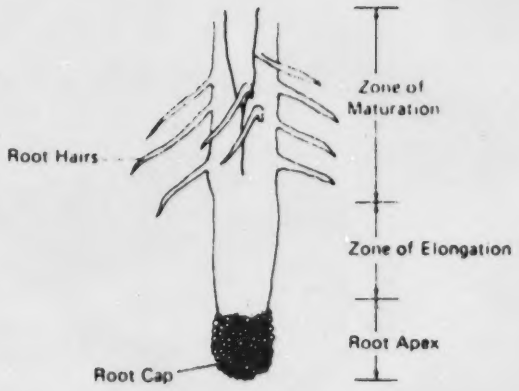


taproot-pecan

fibrous-strawberry

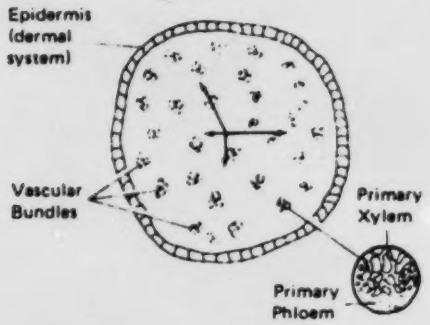
storage taproot-carrot

9.3: REGIONS OF A GROWING ROOT

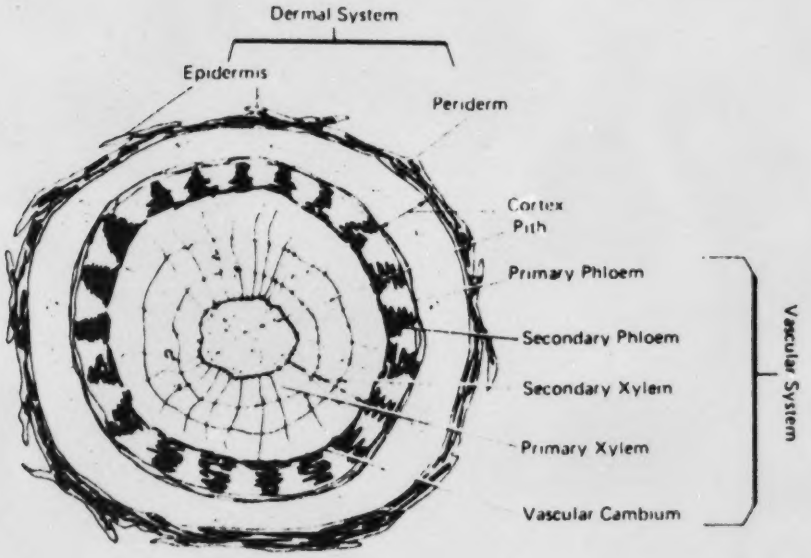


(B)

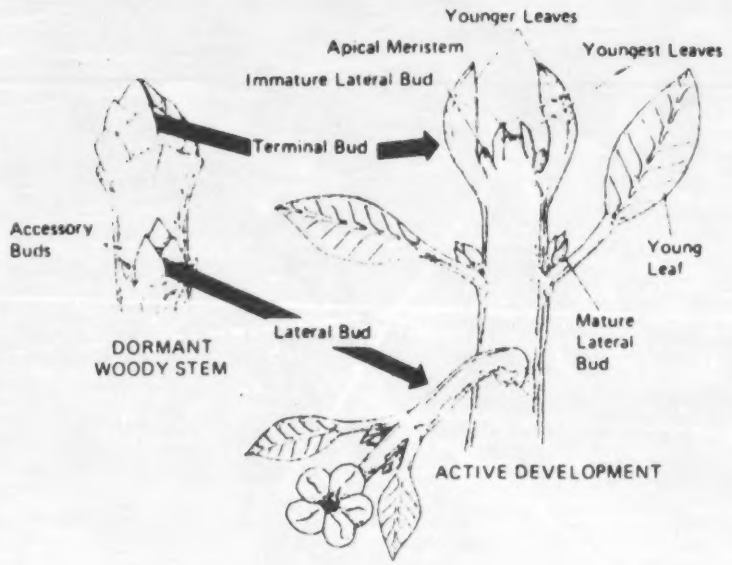
9.4: CROSS-SECTIONS THROUGH THE MATURE MONOCOT STEM



9.5: CROSS-SECTION THROUGH A WOODY DICOT STEM

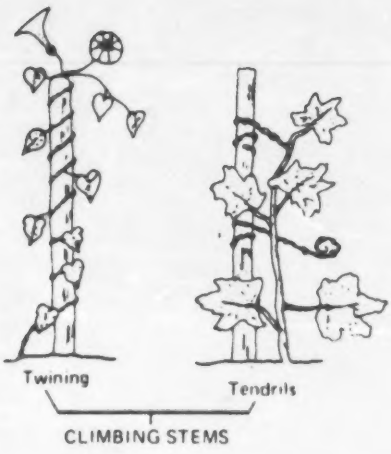


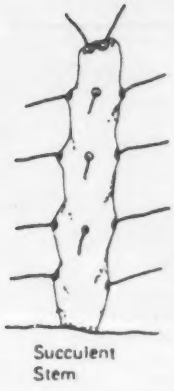
9.6: BUD AND SHOOT DEVELOPMENT

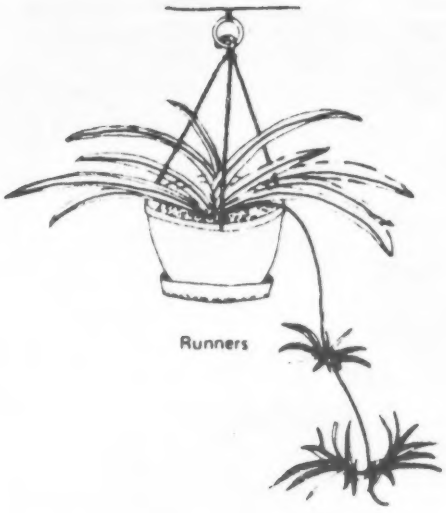


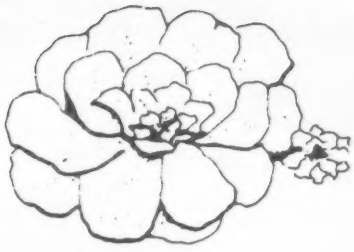
Terminal buds contain an apical meristem and are found on tips of growing shoots. These are involved in increase of stem length and production of leaves and lateral buds (leafy stems). They may also give rise to flowers in some cases. Lateral buds give rise to leafy stems and/or flowers. Accessory buds can produce (when present) similar structures in event of lateral bud destruction. While buds are found both on herbaceous and woody plants, they are more pronounced in the latter case, especially dormant buds.

9.7: ABOVE GROUND STEM MODIFICATIONS



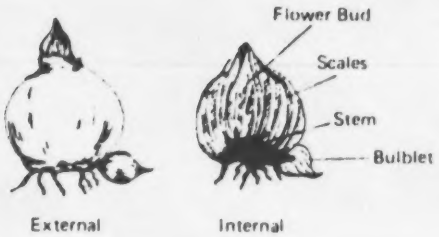






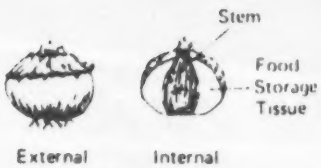
Climbing stems are represented here by morning glory (left) and grape (right). Grape (*Vitus* cultivars) tendrils are also modified stems, but most climbing stem tendrils are modified leaves. Others are succulent stems (*Euphorbia*), runners (Spider plant, *Chlorophytum*), offsets (*Echeveria*).

9.8: BELOW-GROUND STEM MODIFICATION



LAMINATE BULB

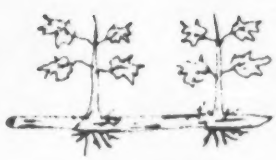
SCALY BULB



CORM

PACHYMORPH
RHIZOME

LEPTOMORPH
RHIZOME



STOLON

TUBER

SUCKER

The laminate bulb is represented here by hyacinth (*Hyacinthus*), scaly bulb by lily (*Lilium*), corm by *Crocus*, pachymorph and leptomorph rhizomes by *Iris* and lily-of-the-valley respectively, stolon by mint (*Mentha* sp.), sucker by red raspberry (cultivars of *Rubus*), and tuber by white potato (cultivars of *Solanum tuberosum*).

GLOSSARY: UNIT NINE

1. Adventituous roots: Roots which develop from areas in the plant by chance; where roots normally would not be expected to be found.

2. Bud Scales: Rudimentary leaves; often found protecting apical buds or young flowers.

3. Cambuim: A layer of meristematic tissue that lies under the bark and which produces xylem and phloem tissue known as secondary wood.

4. Internode: A section of stem which seperates two nodes.

5. Node: A place on the stem where a leaf is attached. It usually includes a lateral bud and/or flower buds.

6. Root Hairs: Small extensions of root epidermal cells, found at the ends of rapidally growing roots. This structure is the chief absorptive structure for roots.

7. Pholem: A vascular tissue found in higher plants; conducts sugar from the leaves to other parts of the plant.

8. Vascular Bundle: In plants, a group of longitudinal supporting and conducting tissue containing xylem and phloem.

9. Xylem: A vascular tissue through which most of the water and minerals are conducted from the roots to other parts of the plant.